



## Application of the wind atlas for Egypt

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# Application of the Wind Atlas for Egypt

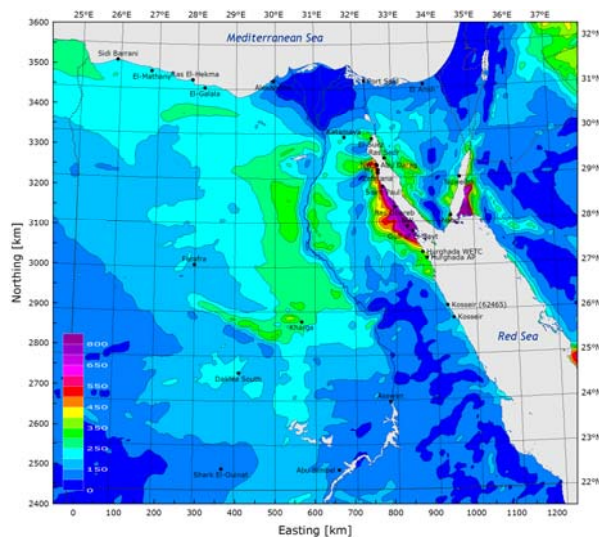
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Wind Energy Department  
Risø National Laboratory

Final Workshop  
6 December 2005

## Wind resource assessment and siting

- Application 1: Overview of Egyptian wind resources
  - Input: numerical wind atlas database
  - Output: Maps, statistics, ...
- Application 2: Numerical wind atlas + WAsP
  - Input: numerical wind atlas database
  - Output: WAsP results (wind climates, power productions,...)
- Application 3: Observational wind atlas + WAsP
  - Input: observational wind atlas
  - Output: WAsP results (wind climates, power productions,...)
- Topographical inputs
- Summary
- The future...

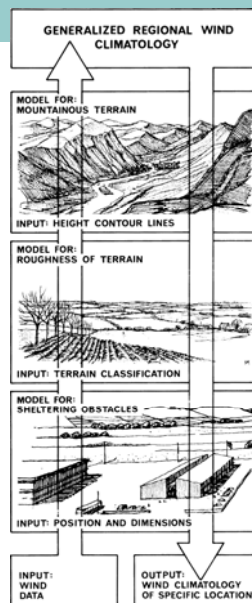
## 1. Overview of Egyptian wind resources



- KAMM modelling
- Resolution 7.5 km
- Map shows PWC
- Wind climate over actual terrain surface
- Mean power density 50 m a.g.l. [ $\text{Wm}^{-2}$ ]
- Linear PD scale
- Output format:
  - map graphic
  - statistics
  - ...

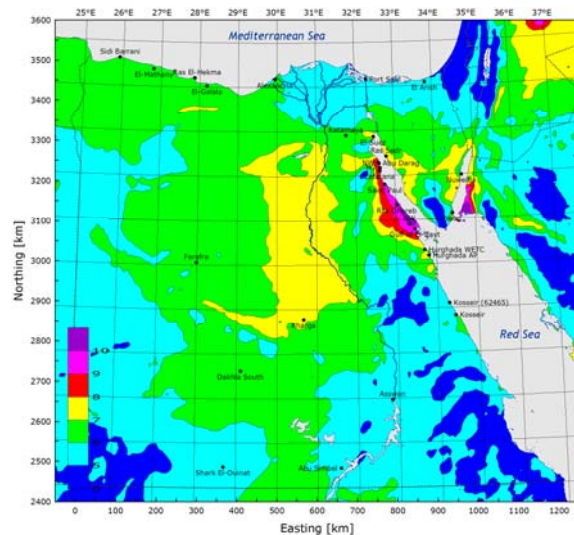
## 2. Numerical wind atlas

- Analysis procedure (KAMM)
  - NCEP/NCAR reanalysis data**
  - + roughness map
  - + elevation map
  - ⇒ **Regional Wind Climate**
- Application procedure (WAsP)
  - Regional Wind Climate**
  - + sheltering obstacles
  - + roughness map
  - + elevation map
  - ⇒ **Predicted Wind Climate**
  - + power and thrust curves
  - ⇒ **Predicted wind farm AEP**



## Regional wind climate

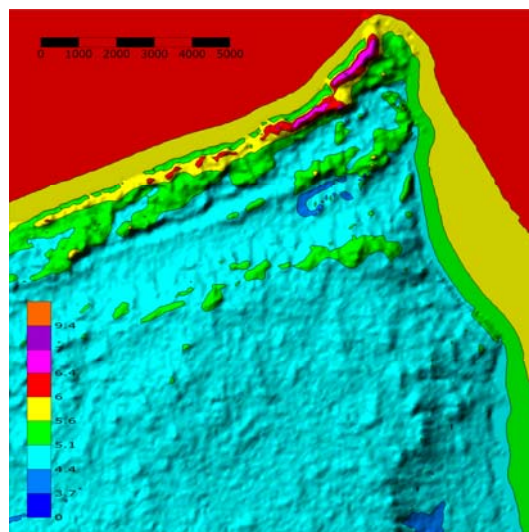
RISØ



- KAMM modelling
- Resolution 7.5 km
- Map shows RWC
- Wind climate over flat, uniform terrain
- Mean wind speed 50 m a.g.l. [ $\text{ms}^{-1}$ ]
- Linear speed scale
- Output format: WAsP \*.lib file
  - Weibull A and k
  - Standard heights
  - Standard  $z_0$

## Detailed wind resources at Ras El-Hekma

RISØ



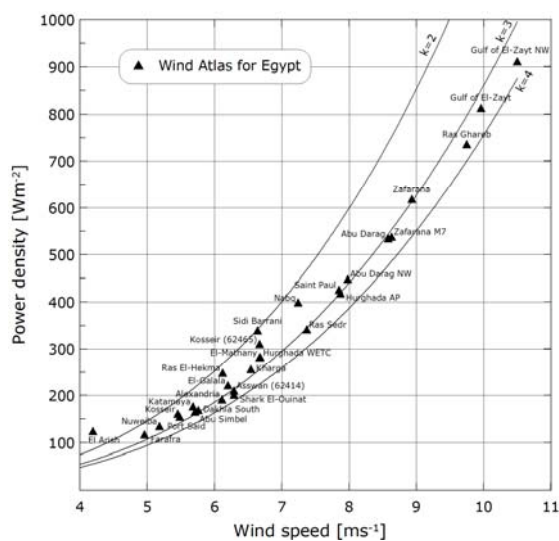
- WAsP modelling of detailed wind speed @ 10 m a.g.l.
- Resolution 100 m
- KAMM wind map indicates Class 2
- Offshore resource is higher: Class 5
- Coastal resource is higher: Class 3/4
- Hill/ridge resource is higher: Class 6

## RISØ

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- ```

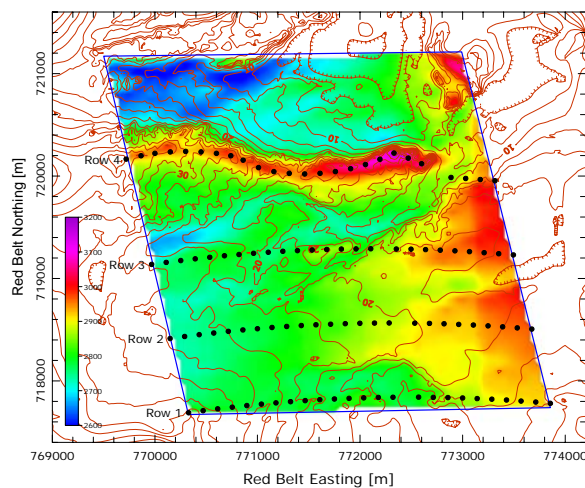
graph TD
    A[INPUT: WIND DATA] --> B[MODEL FOR: MOUNTAINOUS TERRAIN]
    A --> C[MODEL FOR: ROUGHNESS OF TERRAIN]
    A --> D[MODEL FOR: SHELTERING OBSTACLES]
    B --> E[ ]
    C --> E
    D --> E
    E --> F[OUTPUT: WIND CLIMATOLOGY OF SPECIFIC LOCATION]
    style E width:0px,height:0px
  
```
- GENERALIZED REGIONAL WIND CLIMATOLOGY**
- MODEL FOR: MOUNTAINOUS TERRAIN**
- INPUT: HEIGHT CONTOUR LINES
- MODEL FOR: ROUGHNESS OF TERRAIN**
- INPUT: TERRAIN CLASSIFICATION
- MODEL FOR: SHELTERING OBSTACLES**
- INPUT: POSITION AND DIMENSIONS
- INPUT: WIND DATA**
- OUTPUT: WIND CLIMATOLOGY OF SPECIFIC LOCATION**

## RISØ



- WASP modelling
- 30 met. stations
- Graph shows RWC
- Wind climate over flat, uniform terrain
- Mean wind speed and power density 50 m a.g.l.
- Output format:  
WASP \*.lib file
  - Weibull  $A$  and  $k$
  - Standard heights
  - Standard  $z_0$

## Detailed wind resources at Zafarana



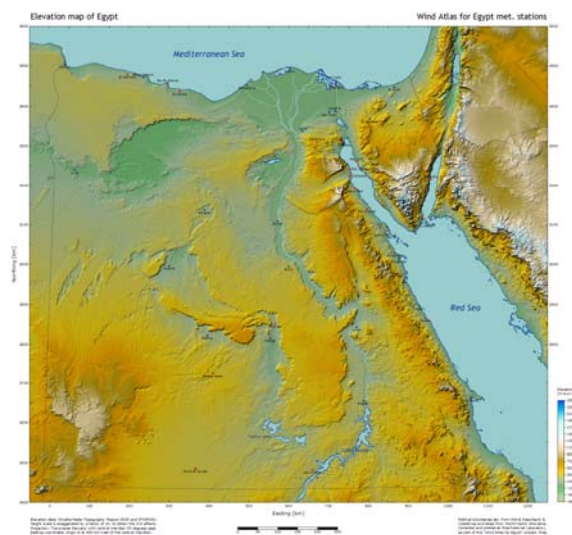
## Topographical inputs for WAsP

- Elevation map
  - Shuttle Radar Topography Mission elevation data
  - Digitised topographical map
- Roughness (land-use) map
  - SRTM Water Body Data
  - Satellite imagery
  - Digitised topographical map
  - Aerial photography
- Obstacle description
  - Site visit



## Shuttle Radar Topography Mission

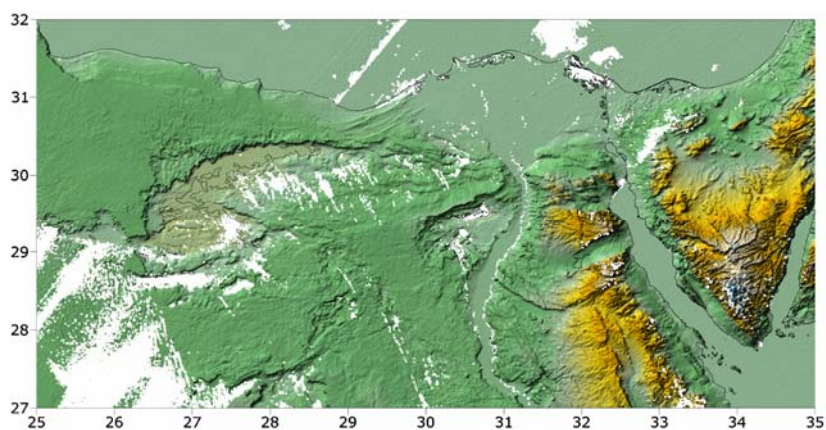
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- Grid point elevations
- 3" (~90 m) resolution
- Vertical accuracy 5-10 m

## Inspection of raw SRTM data

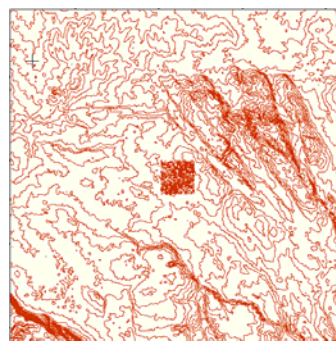
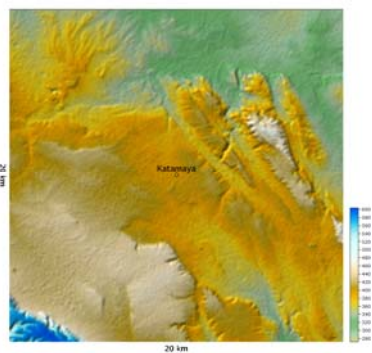
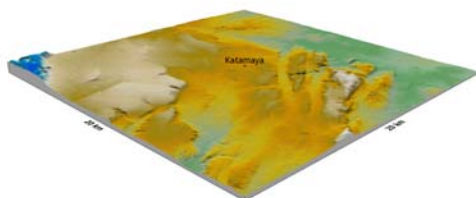
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- Check for missing information (voids = white)
- Check for spikes and wells

## Katamaya elevation map from SRTM data

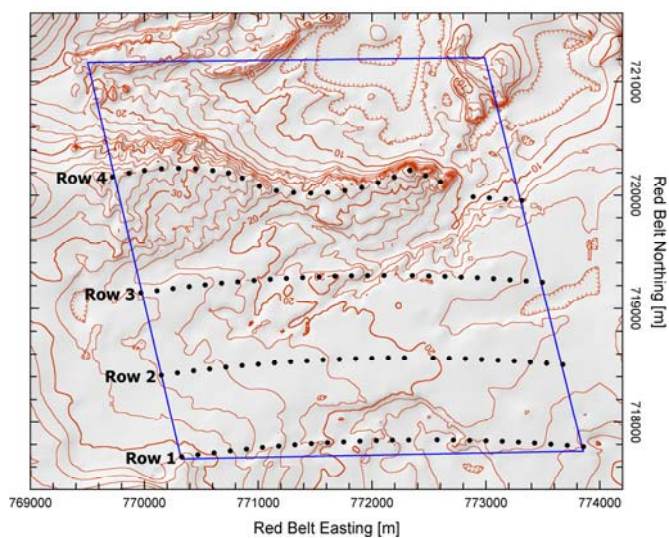
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20×20 km with 10-m contours  
2×2 km with 1-m contours

## Zafarana elevation map from surveying

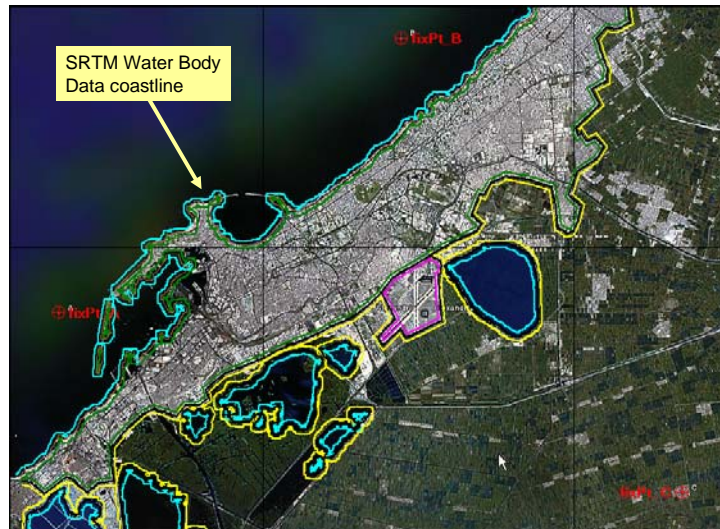
RISØ





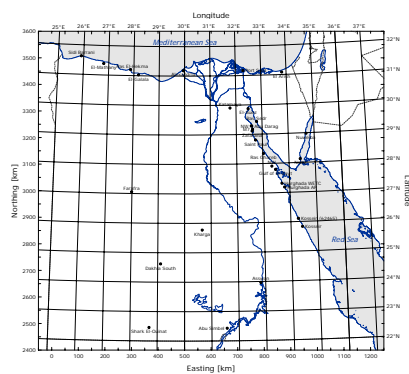
## Alexandria roughness map from Google Earth

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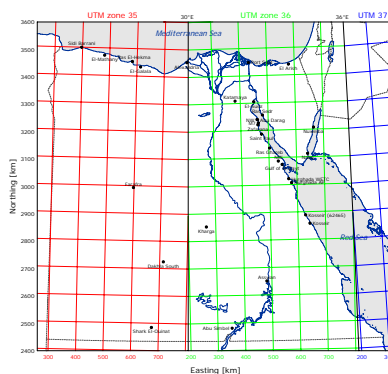


## Coordinate systems

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- Geographical latitude/longitude
- World Geodetic System 1984



- Universal Transverse Mercator
- World Geodetic System 1984
- UTM zones 35, 36, 37

## Summary – a complete package



- Wind-climatological inputs
  - Numerical wind atlas (all over Egypt)
  - Observational wind atlas (30+ stations)
- Topographical inputs
  - SRTM elevation data (free Internet download)
  - SRTM Water Body Data (free Internet download)
  - Google Earth satellite imagery (free & licensed versions)
- Software tools
  - WAsP, Map Editor, Utility Programs
  - Surfer, Grapher, Didger
- Other resources
  - Wind atlases, wind farm planning report, training, ...

## The future...



- Numerical wind atlas
  - Long-term data (1968-95) – infrequent updating ok
- Observational wind atlas
  - Some reference met. stations should continue
  - New measurement programmes may be initiated
  - Cup anemometers must be rehabilitated and recalibrated
  - Databases can be updated and extended
  - Wind Atlas for Egypt can be updated

Conclusion: the present approach to wind resource assessment and siting may be continued for several years.

*– I wish you all the best for your future work!*